Reduction of chemical load in crop production due to silatrans

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Abstract. The article is devoted to the study of the possibility of increasing the yield of oats and winter rye without increasing the doses of mineral fertilizers due to bionutrients based on silatrans that are safe for humans and animals. The objectives of the research were to identify the effect of silatrans on yield and to determine the contribution of biometric indicators of plant productivity to the harvest and to study the effect of biologically active substances on the main indicators of grain quality of winter rye and oats. As a result of research, it was found that seed treatment with Silatran causes a significant and significant increase in field germination of oat seeds. The bionutrient enhances the growth of the root system of oat plants at the initial and subsequent stages of vegetation. A significant increase (2.2 c/ha) of the oat harvest was obtained in the variant with the treatment of Silatran crops in the tillering phase of plants. 3-fold use of this drug (seed treatment and tillering and sweeping of crops) has led to a significant increase in yield. On winter rye crops, reliable increases were obtained in variants with 2-fold treatment of Silatran crops. A significant increase in the protein content of winter rye grain was found with 2-fold treatment of crops with Silatran preparation. In general, it can be noted that the studied crops show the possibility of a noticeable increase in yield without increasing doses of mineral fertilizers. This can reduce the chemical load in crop production with corresponding environmental consequences.

1 Introduction

Traditional chemicalization of crop production leads to chemicalization of food products, disruption of the ecological balance and, as a result, to a serious deterioration in public health [1-2]. Many researchers associate the intensive chemicalization of agriculture in the period of the 60s - 80s of the last century with the growth of health problems of all the population [3-4]. The long-term use of mineral fertilizers and pesticides in huge agricultural and forest areas, often with the use of aviation, has led to large-scale environmental pollution [6-8].

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Molecules of pesticides (especially persistent compounds) are included in the natural processes of migration and circulation of substances and are carried along with atmospheric flows over long distances. But most importantly, they are included in the ecological food chains: from the soil they enter water and plants, then into the organisms of animals and birds, and ultimately, with food and water, into the human body. And at every stage of migration, they cause harm and damage.

If by the beginning of the sixties of the last century there were 5 kg of chemical products used in agriculture per capita, 0.74% of the total number of children with genetic abnormalities were born, then by the end of the eighties the mass of chemicals entering the agricultural lands of the country increased to 25 kg per capita The number of children born with genetic disorders., increased to 16.5%. Biologists have long established that a population that is 30% "corrupted" genetically is doomed to degeneration.

It is no secret that the chemicalization of crop production leads to the chemicalization of food products, disruption of the ecological balance and, as a result, to a serious deterioration in public health, disruption of the ecological balance, decreased reproductive functions and the birth of children with various developmental disorders.

Statistics show that the dynamics of the growth in the number of cancer patients also correlates with the dynamics of the use of mineral fertilizers and pesticides. And this is in no way consistent with demographic policy, concern for the health of the nation, or ensuring one of the most important criteria for food security.

It is known that with the traditional approach to increasing yields, an increasing dose of mineral fertilizers and pesticides is required for each subsequent hundredweight achieved. And this is not only a problem of the environment and the health of the nation. It is also a problem of profitability and competitiveness of agricultural business in conditions of constant growth of prices for agrochemicals [9-11].

With an increase in the volume of fertilizers applied in the USSR from 1960 to 1980 by almost 10 times (from 13.9 million tons to 135 million tons), grain yields increased by no more than 2 times (from 13 c/ha to 18 c/ha). The same trend is observed now. The consumption of mineral fertilizers in Russia has increased 2.5 times over the past 10 years. In 2024 alone, the application of fertilizers increased from 60 to 65 kg/ha (in active substance). However, there was no proportional increase in yields. According to the Ministry of Agriculture of the Russian Federation, from 2013 to 2024, grain harvest increased 1.4 times — from 92.4 million tons to about 129.8 million tons.

At the same time, without the use of mineral fertilizers and plant protection products, it is impossible not only to increase the volume of agricultural products, but also to ensure the country's food security [3, 4].

However, in modern conditions, it is important for the country to ensure food security in full understanding that food is not a solution to hunger problems, but the key to the health of the nation, saving people and solving demographic problems. Not forgetting about the need to increase yields and the environment.

It is time to rethink the strategy of agricultural development and change priorities. Farming technologies should be considered not only from the point of view of increasing yields and increasing profitability, but also ensuring the safety of agriculture for the population of our country in the full understanding of food security in the interpretation of the FAO. Thus, farmers face a dilemma: they need to increase yields by providing physical, social and economic access to sufficient food, but at the same time ensure its safety and the safety of management for the population.

But for investors, first of all, the profitability of business, the competitiveness of agricultural enterprises is important, and it is possible to change the guidelines only by finding compromises, for example, through environmental regulation, introducing the concept of the best available technologies in agriculture. And there are such farms and many of them are successfully used.

The search for effective ways of a reasonable approach to the chemicalization of agriculture has been going on for many decades both in Russia and abroad [4-6]. The greatest attention is paid to improving the efficiency of nutrient absorption of mineral fertilizers and increasing the climatic stability of plants during seed treatment and foliar treatment of plants with various bionutrients [10-11].

For example, these can be humates of various origins or silatrans and other components of organosilicon compounds – products that do not create a load on the ecosystem, but allow improving metabolic processes in plant organisms, increasing the efficiency of using nutrients from mineral fertilizers, and reducing the need for pesticides [9]. As an example, let's further consider the effectiveness of introducing sidatrans into farming technologies to increase yields without increasing doses of mineral fertilizers. The molecules of these compounds have an affinity for the membrane-cell matrix, easily penetrate into the plant cell during seed treatment or spraying of plants, and are quickly included in the system of hormonal regulation of plant vital activity and its ontogenesis [10, 11].

It has been established that the biological activity of silatrans is due to their unique molecular structure, the presence of a silicon atom and a specific electronic configuration. Their wide range of biological effects as a new type of biostimulants of metabolic processes allows them to be successfully used in the cultivation of industrial crops [10,11]. It is important to understand the practical applicability of silatrans to improve metabolic processes and increase the yield of industrial crops without increasing doses of mineral fertilizers.

Research objectives:

to identify the effect of the drug on yield and to determine the contribution of biometric indicators of plant productivity to the harvest;

to evaluate the retardant properties of the active substance of the drug

to study the effect of a biologically active substance on the main indicators of grain quality of winter rye and oats.

To implement the tasks set in 2006, the following observations, records and analyses were carried out using well-known techniques.

1. Accounting for laboratory and field germination, sowing density and development of oat plants (biometrics of the root system and green mass of plants during the growing season).
2. Phenological observations.
3. Assessment of lodging resistance and the general condition of plants and crops before harvesting.
4. Crop accounting and crop structure analysis.
5. Evaluation of the main indicators of grain quality: protein content, fat content, the indicator "number of drops", grain type, weight of 1000 grains.
6. Microbiological analysis of grain.

The objects of study were: winter rye (Vyatka 2) and oats (Gyrfalcon).

The scheme of field experiments is presented in Table 1. The accounting area of plots is 10 m2 (oats) and 20 m2 (winter rye), the repetition is 3 times. The placement of plots in experiments is randomized. There were 36 plots in total in the study.

Table 1. Scheme of experience for studying the effectiveness of the drug Silatran on oats and winter rye.

№	Processing option	Agrotechnical term	Purpose of the operation
1	2	3	4
OATS -			
1	Without processing	–	Control – comparison of experimental options

2	Etching	1-2 days before sowing	Etalon – chemical control
3	of Vincite seeds	Just before sowing	An experimental option is to study the productive, adaptive, fungicidal properties of the drug
4	Etching	Etching – before sowing; processing of crops – tillering	An experimental option is to study the yield, adaptive, fungicidal properties of the drug with a combination of processing methods
5	ocessing of Silatran crops	Tillering	An experimental option is to study the productive, adaptive, fungicidal properties of the drug
6	Tillage of crops	Sweeping out	Etalon – chemical control
1	2	3	Control – comparison of experimental options
7	Seed treatment and treatment of Silatran crops	Seed dressing – before sowing; crop treatment – tillering and sweeping	Etalon – chemical control
WINTER RYE			
1	Without processing	–	Control – comparison of experimental options
2	Processing of crops	Spring tillering	An experimental option is to study the productive, adaptive, fungicidal properties of the drug
3	Silatran	2nd internode	Etalon – chemical control in the assessment of lodging resistance
4	Treatment of crops with Tse-Tse retardants	Earing	An experimental option is to study the yield and fungicidal properties of the drug
5	Processing of Silatran crops	Tillering and earing	An experimental option is to study the yield and fungicidal properties of the drug with multiple use

2 Results and discussion

Pre–sowing treatment of oat seeds with Silatran preparation at the recommended dose contributed to a statistically significant increase in field germination - from 83.0 to 92.2% (Table 2). The number of plants on the registration sites (S = 0.56 m2) in variants with Silatran seed etching (plots 3, 4, 7) significantly exceeded the control and reference variants (Table 3).

It was found that bionutrients did not affect the growth dynamics of the aboveground biomass of oat plants during plant ontogenesis (Table 4). The change in the length of the green mass of oat plants in relation to the control is statistically unreliable. However, a significant increase in the length of the main root was revealed in variants using Silatran. A stronger development of the root system of plants in relation to control was noted in variants with the treatment of crops in the tillering phase and with the joint treatment of seeds and crops.

Table 2. The effect of Silatron on the germination of Gyrfalcon oat seeds (average of 3 repetitions).

Option	Plants per m2		Field germination		Laboratory germination	
	pieces	in % to control	%	in % to control	%	in % to control
Control – without processing	498	–	83.0	–	93.0	-
Seed pickling - pickling agent Vincite	458	92	76.3	92	92.1	99
Seed treatment with Silatran	553	**111**	92.2	**111**	93.6	101

The smallest significant difference,05	10.1					

Table 3. Completeness of oat seedlings at the accounting sites (S = 0.56 m2).

Plot number	Processing option	otal plants, pcs.	on average, pcs.	in % to control
1	Control – without processing	279	93.0	–
2	Etching of Vincite seeds	257	85.7	92.2
3	Etching of Silatran seeds	310	103.3	**111.1**
4	Seed treatment and treatment of Silatran crops	322	107.3	**115.4***
5	Processing of Silatran crops (tillering)	262	87.3	93.9
6	Tillage of crops	257	85.7	92.2
7	(sweeping)	321	107	**115.1***
	P = 5,65 % The smallest significant difference, 05		15.1	

* – reliable for control at P > 0.95 %

In winter rye crops of Vyatka 2, there was also no stimulation and inhibition of plant growth during the processing of Silatran crops. The height of plants decreased only from the treatment of crops with Tse-Tse retardants (Table 5). However, by the flowering phase, the inhibitory effect of the retordant was leveled, and the height of plants in this variant was already at the control level.

Table 4. Study of the growth-stimulating pro perties of the drug Silatran on crops of Gyrfalcon oats (average of 3 repetitions.

Processing option Control – without processing	The length of the green mass by phases						The length of the root system by phases					
	phase 3of the leaves		sweeping out		full ripeness		phase 3of the leaves		sweeping out		full ripeness	
	cm	% to control	cm	% to control	cm	% to control	cm	% to control	cm	% to control.	cm	% to control
Vincite –	19.2	-	67.2	-	73.5	–	3.3	-	4.7	-	6.8	–
seed treatment	16.7*	87.0	67.4	100.3	72.8	99.0	3.3	0	5.0	106.4	6.9	101.5
Silatran – seed treatment	18.8	93.8	69.1	102.8	73.3	100	**4.4***	133.3	5.2	110.6	6.9	101.5

Silatran – seed pickling + crop treatment (tillering)	-	-	67.3	100	75.1	102.2	-	-	**6.8***	144.7	**7.5***	110.3
Silatran – processing of crops (tillering)	-	-	66.3	98.7	74.8	101.8	-	-	**6.0***	127.7	**7.2***	105.9
Silatran – seed pickling + crop treatment (tillering and earing)	-	-	-	-	72.6	98.8	-	-	-	-	7.0	102.9

* – reliable for control at P > 0.95 %

Table 5. Dynamics of growth of winter rye plants of Vyatka 2 variety (average of 3 repetitions).

Processing option	Plant height, cm						Lodging resistance, score
	Earing		Blossom		Full ripeness		
	sm	% to control	sm	% to control	sm	% to control	
Control –without processing	131	–	174	–	182	-	2.0
Processing of crops Silatran (tillering)	130	99	170	99	178	98	2.3
Treatment of crops with a Tse-Tse-Tse retardant (2nd internode)	**114***	87	166	95	175	96	2.8
Processing of crops Silatran (earing)	125	95	174	101	177	97	2.3
2-fold processing of Silatran crops (tillering and earing)	126	96	**182***	105	181	99	3.7
The smallest significant difference, 05	4.6		8.3		5.5		0.88

* – reliable for control at P > 0.95 %

Despite the use of growth agents, the resistance of plants to lodging in both experiments was extremely low: from 2.0 to 3.7 points (winter rye) and from 2.7 to 3.8 points (oats) with a 5-point accounting scale. Higher stability (3.7 points) was observed in winter rye in the variant with 2-fold treatment of crops with Silatran, in oats – when processing crops in the tillering phase (3.8 points) (Table 6).

In the agro-climatic conditions, the onset of the phases of vegetation of plants was close to the long-term average values. Against the background of the use of the drug Silatron, earlier (1-2 days) sweeping of the panicle in oats was noted. However, subsequent growing season conditions (heavy rains, high soil and air humidity) offset this fact. As a result, the dates of onset of waxy and full ripeness of the grain were approximately the same in the experimental and control versions (Table 7).

Table 6. Agrobiological characteristics of Gyrfalcon oat crops.

	Option	The date of the phases *	The condition	

Plot num ber		sweeping out	wax ripeness	of the crops before harvesting, point **	Lodging resistance, score **
1	Control – without processing	26.06. … 27.06.	08.08.	3.7	3.3
2.	Etching of Vincite seeds	26.06. … 27.06.	07.08. ...08.08.	3.7	3.3
3	Etching of Silatran seeds	25.06. … 26.06.	08.08.	3.7	3.3
4	Seed treatment and treatment of Silatran crops (tillering)	25.06.	08.08.	3.4	2.8
5	Processing of Silatran crops (tillering)	25.06. … 26.06.	08.08.	3.7	3,8
6	Tillage of crops (sweeping)	26.06. …27.06.	08.08.	3.7	3.7
7	3-fold Silatran treatment	25.06.	07.08. … 08.08.	3.0	2.7

* – date range between repetitions in the experiment
** – 5- a 10-point scale (the average of 3 repetitions)

Thus, we believe that the bio-silicon organic nutrient induces an increase in field germination of seeds and promotes more intensive growth of the root system of oat plants. It can also be reasonably assumed that the drug does not have pronounced retardant properties and does not contribute to increasing the resistance of winter rye and oat plants to lodging.

The growing conditions of grain crops in the Kirov region were generally favorable. Good overwintering of winter rye (90...100%), sufficient precipitation and relatively uniform precipitation, close to optimal temperature conditions contributed to good grain filling and the formation of a sufficiently high yield. However, the same agro-climatic conditions were favorable for the development of fungal infection in crops (Table 7 and Table 8).

In experiments with winter rye Vyatka 2, the highest yield was obtained when crops were treated with a Tse-Tse retardant (36.5 c/ha) and in the variant with 2-fold use of the drug Silatran (36.2 c/ha) (Table 8). In these variants, higher plant resistance to lodging was noted: 2.8 and 3.7 points (see Table 5). A single treatment of winter rye Silatran crops in the tillering or earing phases of plants proved ineffective.

Table 7. Effect of Silatran preparation on oat yield (average of 3 repetitio).

Plot num ber.	Option	Productivity		
		ц/га	+\- to control	% to control
1	Control – without processing	51.1	-	-
2	Etching of Vincite seeds	51.3	+ 0.2	100
3	Etching of Silatran seeds	51.3	+ 0.2	100
4	Seed treatment and treatment of Silatran crops (tillering)	51.9	+ 0.8	102
5	Processing of Silatran crops (tillering)	**53.3***	+ 2.2	104
6	Tillage of crops	**53.5***	+ 2.4	105
7	3-fold Silatran treatment	44.7*	- 6.4	88
	The smallest significant difference, 05	1.4		

* – reliable for control at P > 0.95 %

Table 8. Effect of the drug Silatron on the yield of winter rye (average of 3 repetitions).

	Option	Productivity

Plot number		c/ha	+\- to control	% to control
1	Control – without processing	33.3	-	-
2	Processing of crops	29.6	-3.7	89
3	Silatran (tillering)	**36.5***	+3.2	109
4	Treatment of crops	34.1	+0.8	102
	The smallest significant difference, 05	2.8		

* – reliable for control at P > 0.95 %

Thus, it is possible to draw a preliminary conclusion or a reasonable assumption that the treatment of oat crops by Gyrfalcon Silatran in the tillering phase of plants is more effective than the option with seed pickling. At the same time, 2-fold application of the drug on oats turned out to be ineffective, and on winter rye Vyatka 2, on the contrary, 2-fold treatment contributed to a significant increase in the yield of this long-stem variety.

The content of protein and essential amino acids in the grain of winter rye and oats is the main indicator of the nutritional value of these crops. One of the main signs determining the technological properties of winter rye grain is the state of the carbohydrate-amylase complex, which is determined by the value of the "number of drops" and "height of the amylogram". For oats, an important sign of grain quality is the fat content in it, as well as the film content, which ensures the manufacturability of food and dietary grain production.

Table 9. Variability of some signs of grain quality of oats and rye in the processing of seeds and Silatran crops.

Option	Oats				Winter rye		
	Weight of 1000 grains, g	Grain size, g/l	Content, %		Weight of 1000 grains, g.	falling number, sec/	protein content, %
			protein	fat			
Control – without processing	32.9	449	11.40	2.74	25.8	119	10.93
Etching of Vincite seeds	33.3	440	11.55	2.69	-	-	-
Etching of Silatran seeds	32.3	**461***	11.43	**2.51***	-	-	-
Processing of Silatran crops	32.2	446	11.12*	3.01*	25.4	123	11.02
(tillering)	31.8	443	11.29*	3.02*	-	-	-
Seed treatment + crop treatment (tillering) Silatran	-	-	-	-	24.8	120	11.08
Processing of Silatran crops	-	-	-	-	26.3	106*	**12.10***
(earing)	32.4	439	11.28*	3.03*	-	-	-

* - reliable for control at P > 0.95

Two-time treatment of winter rye crops with Silatran caused a decrease in the "number of falls" indicator (Table 9). Perhaps this is due to the increase in grain size in this variant. As you know, there is a fairly close negative relationship between these signs. However, this fact needs to be checked again in subsequent tests. However, in this variant, a grain with a high protein content was obtained (Table 9). An increase in the "number of falls" indicator was noted during the treatment of crops with a Tse-Tse-Tse retardant, probably due to higher plant resistance to lodging and a decrease in grain germination in the ear.

The fat content in the grain increased in all variants of chemicalization, with the exception of seed pickling Silatran (a significant decrease in fatty acids) and Vincite (a statistically unproven change). It is not yet possible to explain the changes in the biochemistry of the Gyrfalcon oat grain under the influence of the studied drugs. Research needs to be continued.

3 Conclusion

Seed treatment with Silatran causes a significant and significant increase (by 11%) in field germination of oat seeds; laboratory germination practically did not change.

The bionutrient enhances the growth of the root system of oat plants at the initial and subsequent stages of vegetation (phase 3 of leaves - tillering – sweeping). The change in the length of the green mass has not been statistically proven.

A significant increase (2.2 c/ha) in the yield of Gyrfalcon oats was obtained in the variant with the treatment of Silatran crops in the tillering phase of plants.

3-fold use of this drug (seed treatment and tillering and sweeping of crops) has led to a significant increase in yield. The largest increase (2.4 c/g) was obtained in the variant with the treatment of Tilt crops.

On winter rye crops of Vyatka 2, reliable increases were obtained in variants with treatment of crops with a Tse-Tse-Tse retardant (3.2 c/ha) and 2-fold treatment of Silatran crops (2.9 c/ha). The processing of crops in the tillering phase led to a decrease in the yield of winter rye. Perhaps this is due to some delay in processing (due to adverse weather conditions, spraying of crops was carried out during the phase of the appearance of the first internode).

A significant increase in the protein content of winter rye grain was found with 2-fold treatment of crops with Silatran preparation. The decrease in the number of drops in this variant is due to the existing negative correlation between grain size and the number of drops. There is also an opinion that there is a negative relationship between protein content and the activity of amylolytic processes and rye.

In general, it can be noted that the studied crops show the possibility of a noticeable increase in yield without increasing doses of mineral fertilizers. This can reduce the chemical load in crop production with corresponding environmental consequences.

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